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(71) Applicant *(for all designated States except US)*: NOKIA TELECOMMUNICATIONS OY [FI/FI]; Mäkkylän puistotie 1, FIN-02600 Espoo (FI).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: VIKAMAA, Sakari [FI/FI]; Varpusentie 25, FIN-90540 Oulu (FI).

(74) Agent: OY KOLSTER AB; Iso Roobertinkatu 23, P.O. Box 148, FIN-00121 Helsinki (FI).

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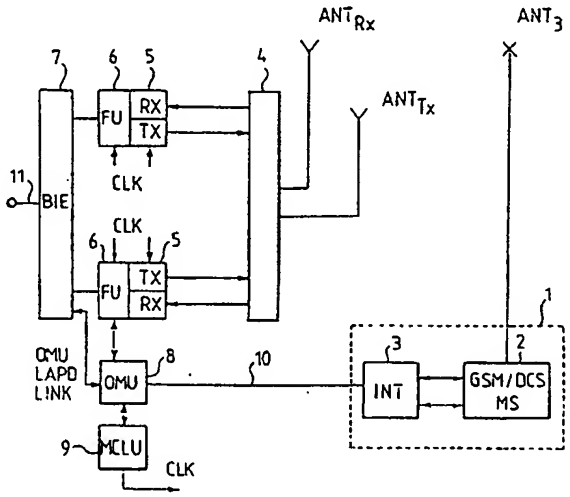

(57) Abstract

The invention relates to a base station for a TDMA cellular radio network, comprising clock means (9) for generating a transmission clock and a TDMA frame clock, transceiver means (4, 5, 6) for transmitting a TDMA signal synchronized with the transmission and frame clock at least at one assigned carrier frequency, which TDMA signal consists of a succession of TDMA frames containing time slots utilized as traffic and control channels, whereby a frame synchronization information, a base station information and/or a time synchronization information is transmitted in the control channel time slots of predetermined frames of the TDMA signal for a synchronization of subscriber radio stations with the base station. The base station according to the invention comprises further an additional receiver equipment (1) for receiving a TDMA signal of at least one predetermined neighbouring base station and for deriving the frame synchronization information and/or the time synchronization information from the received signal. The clock means (9) are responsive to said derived frame and/or time synchronization information for a frame and/or time synchronization of the base station with one or several neighbouring base station(s).

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Base station for a TDMA cellular radio network

Field of the Invention

The invention relates to a base station for a TDMA cellular radio network, comprising

clock means for generating a transmission clock and a TDMA frame clock,

transceiver means for transmitting a TDMA signal synchronized with the transmission and frame clock at least at one assigned carrier frequency, which TDMA signal consists of a succession of TDMA frames containing time slots utilized as traffic and control channels, whereby a frame synchronization information, a base station information and/or a time synchronization information is transmitted in the control channel time slots of predetermined frames of the TDMA signal for a synchronization of subscriber radio stations with the base station.

Background of the Invention

In a cellular radio network, a plurality of base stations are situated in a geographic area covered by the network, through which stations radio telephones moving in the area of the network can establish a radio connection with a fixed network. When a radio telephone is moving from the service area (radio cell) of one base station to the service area of another base station, the radio telephone is synchronized with and engaged to the new base station. The procedure is called a handover. A handover which is as unnoticeable and quick as possible is a normally desired feature, especially when the handover takes place during an active call. Particularly with smaller cell sizes, it is an essential standard of efficiency of the cellular radio network to perform a

handover quickly and unnoticeably. In a TDMA (Time Division Multiple Access) cellular radio network, a synchronization of base stations with each other, e.g. a frequency or frame synchronization, offers advantages for instance in form of a quicker handover. Especially a mutual frame synchronization of base stations is, however, problematic in many networks, as e.g. in the Pan-European mobile telephone system GSM, in which no specific frame synchronization parameter is delivered through the fixed network to the various base stations.

Disclosure of the Invention

The object of the present invention is a base station of a TDMA cellular radio network, capable of being synchronized with the other base stations in the cellular network.

This is achieved by means of a base station of the type described in the prior art portion, which base station is according to the invention characterized in that the base station further comprises an additional receiver equipment for receiving a TDMA signal from at least one predetermined neighbouring base station and for deriving the frame synchronization information and/or the time synchronization information from the received signal, and that said clock means are responsive to said derived frame and/or time synchronization information for a frame and/or time synchronization of the base station with one or several neighbouring base station(s).

In the invention, a base station is synchronized with a neighbouring base station over a radio path by utilizing the synchronization information transmitted by the neighbouring base station to its subscriber radio stations. For this purpose, the base

station is provided with an equipment for receiving the base station information, the time synchronization information (timing advance information) and the frame synchronization information (frame number) transmitted by the neighbouring base station. By means of the base station information, the equipment identifies the neighbouring base station. The equipment synchronizes the base station with the neighbouring base station by forwarding the received time synchronization and/or frame synchronization information to a clock unit of the base station. Various groups of neighbouring cells can be defined for the equipment in such a way that the equipment is capable of monitoring transmissions from several neighbouring base stations. It is thereby possible to determine an average of measurements of different neighbouring base stations, due to which the base station can be synchronized as well as possible compared with the neighbouring base stations (cells). The equipment may provide the synchronization information of an individual neighbouring base station with an accuracy of about a quarter bit (about 0,9 µs in the GSM system), which accuracy can be improved by above-mentioned averaging. In the GSM system, the equipment receives the frame number information on a broadcasting channel BCCH of the neighbouring base station and the timing advance information in an access grant message transmitted by the neighbouring base station on a common control channel CCCH as a random access acknowledgement.

Brief Description of the Drawings

In the following, the invention will be explained in more detail by means of illustrating embodiments with reference to the attached drawing, in

which

Figure 1 shows a block diagram of a base station according to the invention,

Figure 2 shows a block diagram of a mobile telephone suitable for being used in a testing device,

Figure 3 shows a block diagram of a cellular radio system utilizing base stations according to the invention,

Figures 4A, 4B, 4C and 4D illustrate a TDMA frame structure and Figure 4E illustrates a synchronization burst transmitted in one control channel time slot, and

Figure 5 illustrates an occurrence of various control channels in a control channel multiframe.

A detailed Description of the Invention

The present invention is suitable for being applied to all TDMA cellular radio systems, such as the Pan-European mobile telephone system GSM, the DCS1800 (Digital Cellular System) and PCN. The invention will be described below by using the implementation of a base station in the GSM system as a primary example.

The base station of Figure 1 comprises a baseband interface equipment 7, by means of which the base station is connected to a digital signal, typically a PCM signal, from a base station controller BSC and a mobile telephone exchange MSC. User data and control data received from a link 11 are inserted in TDMA frames in a frame unit 6, channel coded, interleaved and transmitted as TDMA bursts and modulated in a transceiver unit 5 to a desired transmitting carrier and applied through transmitting filters 4 to a transmitting antenna ANT_{TX}. Respectively, a TDMA signal received by a receiving antenna ANT_{RX} is ap-

plied through the transmitting filters 4 to the transceiver unit 5, in which it is demodulated from the receiving carrier to the baseband frequency, followed by detection, de-interleaving, channel decoding and deframing in the frame unit 6, and then the received control and user data are applied over the interface 7 to the PCM link 11. The base station may comprise several assigned transmitting and receiving carrier pairs and a corresponding number of transceiver units 5 and frame units 6. All clock signals required by the base station are typically derived from a master clock generated by a master clock unit 9 of the base station. Such clock and timing signals are e.g. a frame clock and a frame number information required by the frame unit 6 and a transmission clock required by the transceiver 5. In Figure 1, all these clock signals are indicated by a common symbol CLK. The frame format of the GSM system is illustrated in Figures 4A to 4E. Figure 4D presents one basic TDMA frame containing preferably eight time slots utilized as traffic and control channels. A succession of 51 TDMA frames is one multiframe illustrated in Figure 4C. On the other hand, a superframe consists of a succession of 26 multiframes, as illustrated in Figure 4B. Moreover, a hyperframe consists of 2048 superframes, as illustrated in Figure 4A. Alternatively, one multiframe may contain 26 TDMA frames, whereby one superframe contains 51 multiframes. In Figure 1, a TDMA frame counter included in the clock unit 9 counts from zero to a reading 26 * 51 * 2048. Respectively, a time slot counter included in the clock unit 9 counts from zero to seven within one TDMA frame, a bit counter from zero to 156 and a quarter bit counter from zero to 624 within one time slot. These counters define the timing of the transmission

and reception of the entire base station.

The base station transmits frequency correction and synchronization information to mobile radio stations monitoring the base station, at suitable intervals on particular control channels of predetermined TDMA frames. The control channels utilized for this purpose are broadcasting control channels BCCH, synchronizing channels SCH and frequency correction channels FCCH as well as a common control channel CCCH. Figure 5 illustrates one multiframe of a control channel of the GSM system, which multiframe contains above-mentioned control channels (BCCH/CCCH multiframe) and is transmitted from each base station on a predetermined carrier, a so-called BCCH carrier, which is measured by a mobile radio station, on the basis of which measurement the radio station determines, in accordance with predetermined criteria and handover algorithms, whether a change of base station, i.e. a handover, is needed. Frame synchronizing channel SCH (synchronizing burst), which is illustrated in Figure 4E, is repeated in every tenth TDMA in BCCH/CCCH multiframe. The synchronizing burst comprises a synchronizing sequence in the middle and data bits on both sides thereof. At the beginning and end of a synchronizing burst there are three tail bits. At the end of the burst, there is additionally a particular guard time before the beginning of the following time slot. The mobile radio station decodes the received synchronizing burst and synchronizes its TDMA frame counter, time slot counter, bit counter and quarter bit counter. Moreover, the base station transmits timing advance information in a so-called access grant message on the control channels CCCH of Figure 5.

For a base station handover as quick and unno-

ticeable as possible, it is preferable that the base station left by the mobile radio station and the base station entered by the mobile radio station are synchronized with each other as well as possible. This means that the master clocks and the frame clocks/frame counters of the base stations should be cophasal and synchronized with each other as well as possible. Although the clock units 9 of the base stations in general are synchronized with a PCM clock derived from the transmission link 11, the master clocks and frame clocks of the different base stations may roam slowly in different directions.

Consequently, in Figure 1, the base station according to the invention is provided with a particular testing equipment 1 situated at the base station site in such a way that it can monitor the transmitters of neighbouring base stations and establish a test call over a neighbouring base station, if necessary. The testing equipment 1 comprises an antenna ANT3, a transceiver equipment 2 and an interface 3, through which the testing equipment 1 is able to communicate over a bus 10 with the clock unit 9 and an operating and maintenance unit 8 of the base station. The basic task of the testing equipment is to monitor the transmission of the neighbouring base station and to extract base station information desired and the frames containing frequency correction, frame synchronization and time synchronization information from a received TDMA signal and to transmit this information to the master clock unit of the base station for a frame and/or time synchronization of the base station with the neighbouring base station. Since the testing equipment 1 receives signalling and utilizes information intended for a mobile radio station, such as a mobile telephone, the most simple way

of implementing the transceiver part 2 of the testing equipment 1 is a conventional subscriber equipment, the functional block diagram of which is shown in Figure 2. The radio parts of the subscriber equipment comprise an antenna 3, a duplex filter 28, a receiver 21, a transmitter 29 and a synthetizer 27. In the receiving direction, there are an A/D converter 22, a detector 23, de-interleaving 24, a channel decoder 25 and a speech decoder 26 as well as a loudspeaker in series with the receiver 21. In the transmitting direction, there is a series connection of a modulator 30, a TDMA burst formation 31, interleaving 32, a channel coder 33 and a speech coder 34 as well as a microphone preceding the transmitter 29. All above-mentioned blocks are controlled by a timing and control unit 35, which also derives the synchronization information utilized in the invention from the received signal. The speech coder 34, the microphone, the speech decoder 26 and the loudspeaker are naturally unnecessary components in view of the invention. The only modification needed is the interface 3, over which the unit 35 may communicate with the units 8 and 9 of the base station, and a software needed for this communication. The synchronization utilizes a so-called timing advance facility of the testing device, by which facility the timing of the transmission of the testing device is controlled, depending on the distance between the testing device and the base station.

The operating and maintenance unit 8 of the base station may define various neighbouring cell definitions for the testing equipment 1 over the bus 10, whereby the testing device may monitor the BCCH carriers of several different neighbouring base stations. At the same time either the clock unit 9 or

the control unit 35 of the testing device 1 may calculate average values of the synchronization information extracted from the signals received from the different neighbouring base stations so that the base station is, on an average, synchronized with several neighbouring base stations as well as possible. In Figure 3 is illustrated a part of a cellular radio network utilizing base stations according to the invention. To the mobile exchanges MSC are connected two base station controllers BSC1 and BSC2 in a star configuration, base stations BTS1, BTS2, BTS3 and BTS4 with their testing devices according to the invention being further connected to the base station controllers in a star configuration by PCM links 11. BTS1 has been selected to be the MASTER base station, with which the other base stations shall be synchronized, if possible. The testing device 1 of the base station BTS2 monitors the transmission of the base station BTS1 and synchronizes the base station BTS2 on the basis of the timing advance and frame number information received from the base station BTS1. Respectively, the testing device 1 of the base station BTS3 synchronizes the base station BTS3 on the basis of the synchronization information received over the radio path from the base station BTS2. In the same way, the base station BTS4 is synchronized with the base station BTS3 on the basis of the information transmitted by the station BTS3. Thus a base station system is provided, whereby it is possible to synchronize neighbouring base stations easily and accurately with each other and to achieve thereby a quicker and more unnoticeable handover.

The figures and the specification attached are only intended to illustrate the present invention. As to the details, the base station according to the

invention may vary within the scope of the attached claims.

Claims:

1. A base station for a TDMA cellular radio network, comprising

clock means (9) for generating a transmission clock and a TDMA frame clock,

transceiver means (4, 5, 6) for transmitting a TDMA signal synchronized with the transmission and frame clock at least at one assigned carrier frequency, which TDMA signal consists of a succession of TDMA frames containing time slots utilized as traffic and control channels, whereby a frame synchronization information, a base station information and/or a time synchronization information is transmitted in the control channel time slots of predetermined frames of the TDMA signal for a synchronization of subscriber radio stations with the base station, c h a r a c t e r i z e d in that the base station further comprises an additional receiver equipment (1) for receiving a TDMA signal from at least one predetermined neighbouring base station and for deriving the frame synchronization information and/or the time synchronization information from the received signal, and that said clock means (9) are responsive to said derived frame and/or time synchronization information for a frame and/or time synchronization of the base station with one or several neighbouring base station(s).

2. A base station according to claim 1, c h a r a c t e r i z e d in that the additional receiver equipment (1) receives a TDMA signal of a neighbouring base station or several neighbouring base stations, and that said clock means (9) are responsive to averages of the frame and time synchronization information derived from different received

signals for a synchronization of the base station with several neighbouring base stations as well as possible.

3. A base station according to claim 1 or 2, c h a r a c t e r i z e d in that the frame synchronization information is a frame number.

4. A base station according to claim 1, 2 or 3, c h a r a c t e r i z e d in that the additional receiver equipment (1) derives the base station information and the frame synchronization information of the neighbouring base station from a synchronizing burst, which is broadcasted by the neighbouring base station to all subscriber radio stations on a broadcasting control channel (BCCH).

5. A base station according to any of the preceding claims, c h a r a c t e r i z e d in that the additional receiver equipment (1) derives the time synchronization information of the neighbouring base station from an access grant message (AGCH) transmitted by the neighbouring base station on a common control channel (CCCH).

6. A base station according to any of the preceding claims, c h a r a c t e r i z e d in that a transmitter equipment is associated to the additional receiver equipment (1), and that the combined transceiver arrangement (2) is capable of simulating a subscriber radio station and of establishing a test call with the neighbouring base station.

1/3

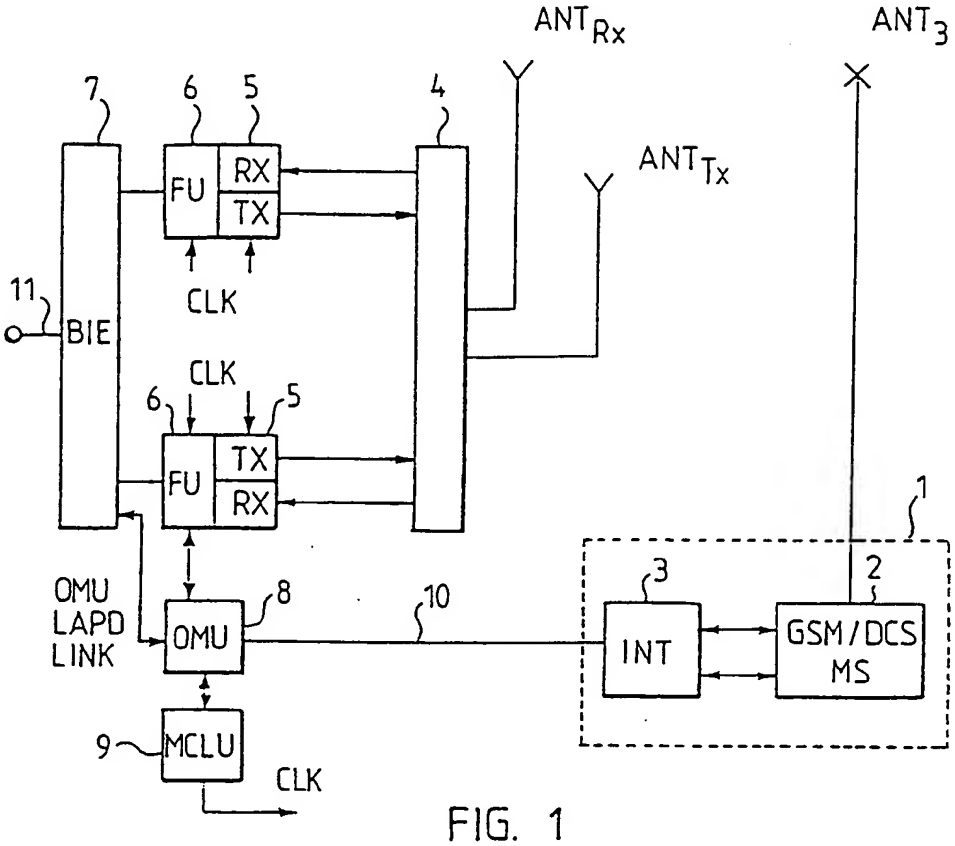


FIG. 1

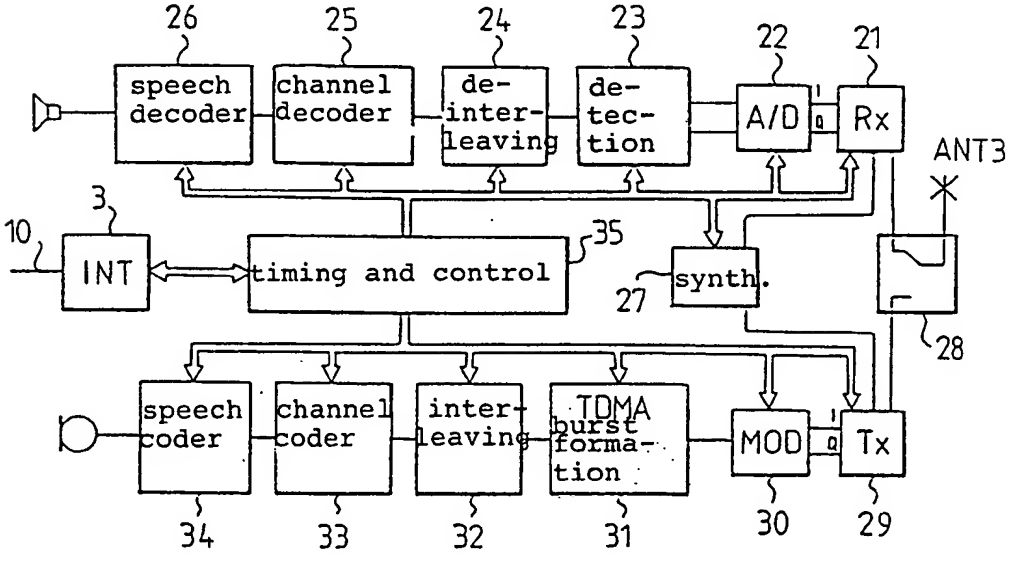
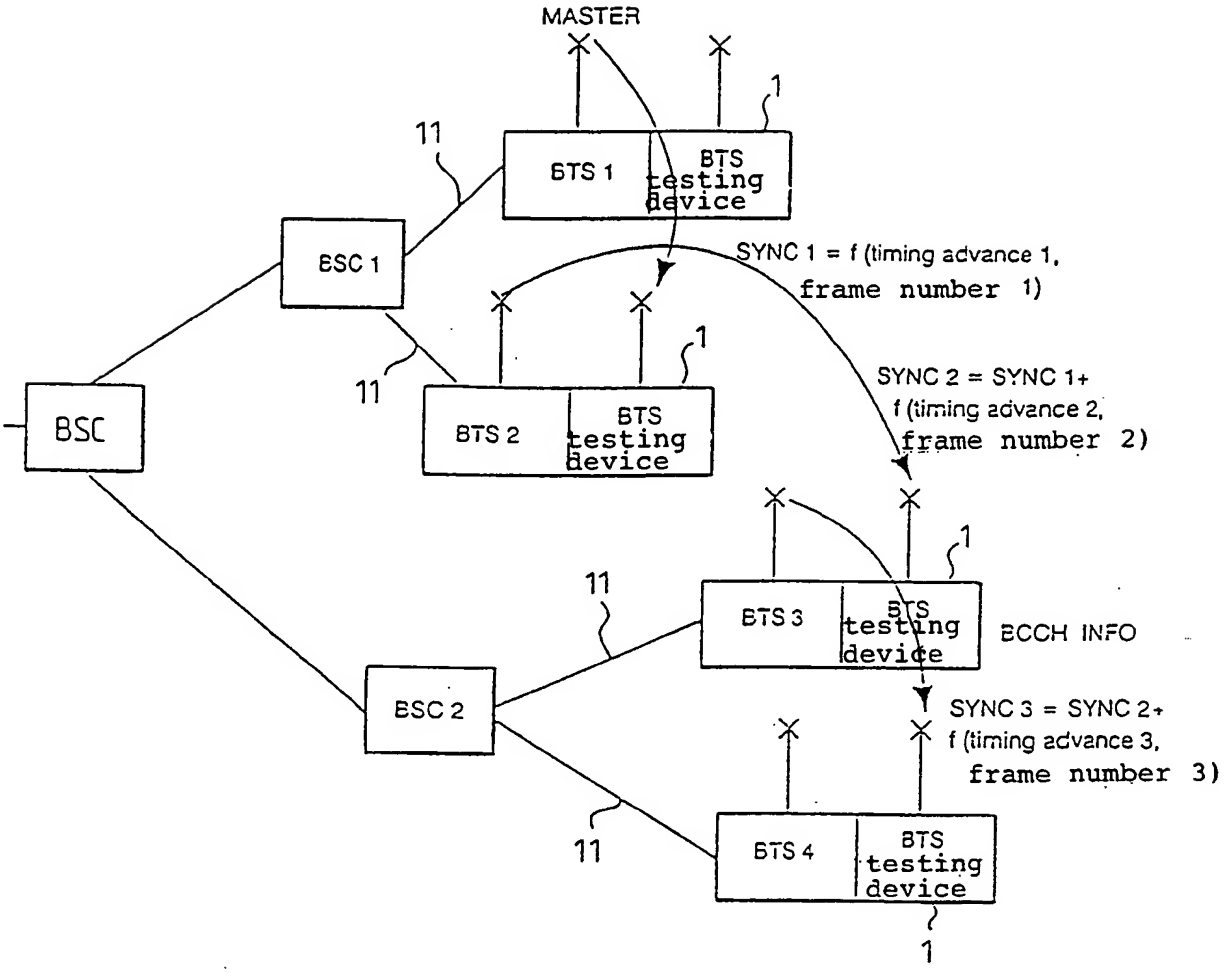


FIG. 2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1
11
BTS 1
BTS testing device
BSC 1
SYNC 1 = f (timing advance 1, frame number 1)
1
11
BTS 2
BTS testing device
SYNC 2 = SYNC 1+ f (timing advance 2, frame number 2)
BSC
1
11
BTS 3
BTS testing device
BCCH INFO
BSC 2
SYNC 3 = SYNC 2+ f (timing advance 3, frame number 3)
11
BTS 4
BTS testing device
1

FIG. 3

FIG. 4A

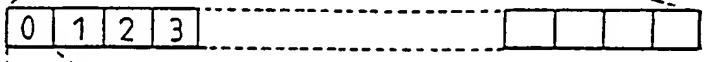

FIG. 4B

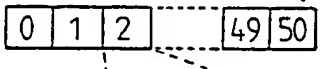

FIG. 4C

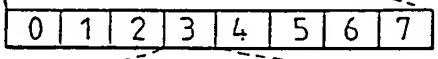

FIG. 4D

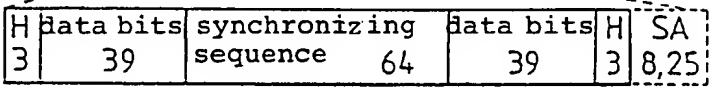

FIG. 4E

f = FCCH
s = SCH
b = BCCH
c = CCCH

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 93/00228

A. CLASSIFICATION OF SUBJECT MATTER

IPC5: H04B 7/26, H04Q 7/00, H04J 3/06
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

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IPC5: H04B, H04J, H04Q

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ORBIT: INSPEC, JAPIO, WPAT

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP, A1, 0286614 (TELEFONAKTIEBOLAGET LM ERICSSON), 12 October 1988 (12.10.88), abstract ---	1-6
X	41st IEEE Vehicular Technology Conference, "Geteway to the Future Technology in Motion", IEEE, 1991, Y Akaiwa et al., "Autonomous Decentralized Inter-Base-Station Synchronization for TDMA Microcellular Systems", pp. 257-262; see pp. 257-258 ---	1-6
A	EP, A2, 0474138 (NOKIA MOBILE PHONES LTD), 11 March 1992 (11.03.92), column 1, line 1 - column 2, line 28 ---	1

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 93/00228

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP, A1, 0437835 (NEC CORPORATION), 24 July 1991 (24.07.91), figure 1, abstract --	1
A	EP, A1, 0398773 (MATRA COMMUNICATION), 22 November 1990 (22.11.90), column 1, line 45 - column 2, line 19, figure 1, claim 1, abstract --	1
A	Patent Abstracts of Japan, Vol 14,No 425, E-977, abstract of JP, A, 2-164140 (NIPPON TELEGR & TELEPH CORP), 25 June 1990 (25.06.90) --	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

27/11/93

International application No.
PCT/FI 93/00228

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A1- 0286614	12/10/88	DE-A- 3866923	30/01/92
		SE-B,C- 457184	05/12/88
		SE-A- 8701414	04/10/88
EP-A2- 0474138	11/03/92	JP-A- 4263524	18/09/92
EP-A1- 0437835	24/07/91	AU-A- 6853890	11/07/91
		JP-A- 3224325	03/10/91
EP-A1- 0398773	22/11/90	AU-B- 622543	09/04/92
		AU-A- 5392590	01/11/90
		CA-A- 2015237	26/10/90
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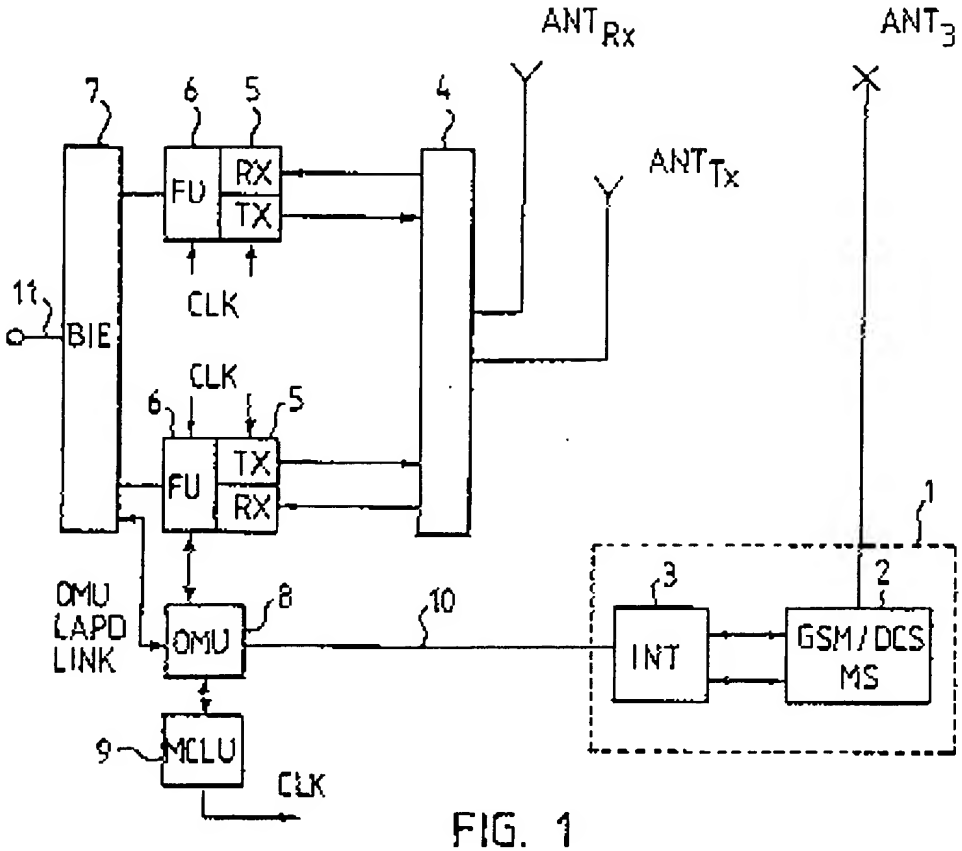
		JP-A- 2302133	14/12/90
		US-A- 5128925	07/07/92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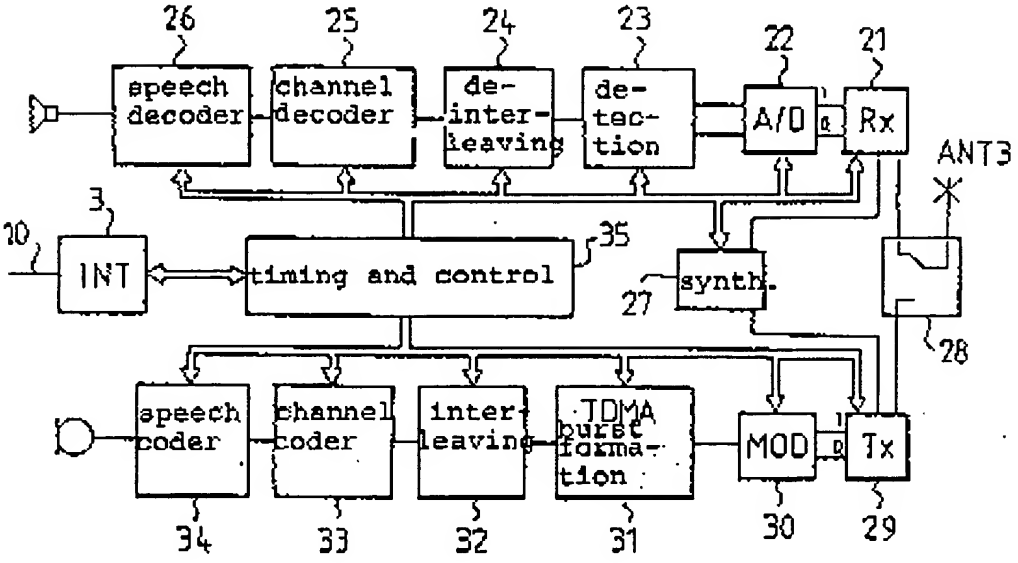
ANT 3
ANT Tx
7
6
5
4
FU
RX
TX
CLK
11
BIE
CLK
6
5
FU
TX
RX
1
OMU LAPD LINK
OMU
8
10
3
2
INT
GSM / DCS MS
9
MCLU
CLK

FIG. 1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25
24
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22
21
speech decoder
channel decoder
de-inter-leaving
de-tec-tion
A/D
Rx
ANT3
3
10
INT
timing and control
35
synth.
27
28
speech coder
channel coder
inter leaving
TDMA burst forma-tion
MOD
Tx
34
33
32
31
30
29

FIG. 2

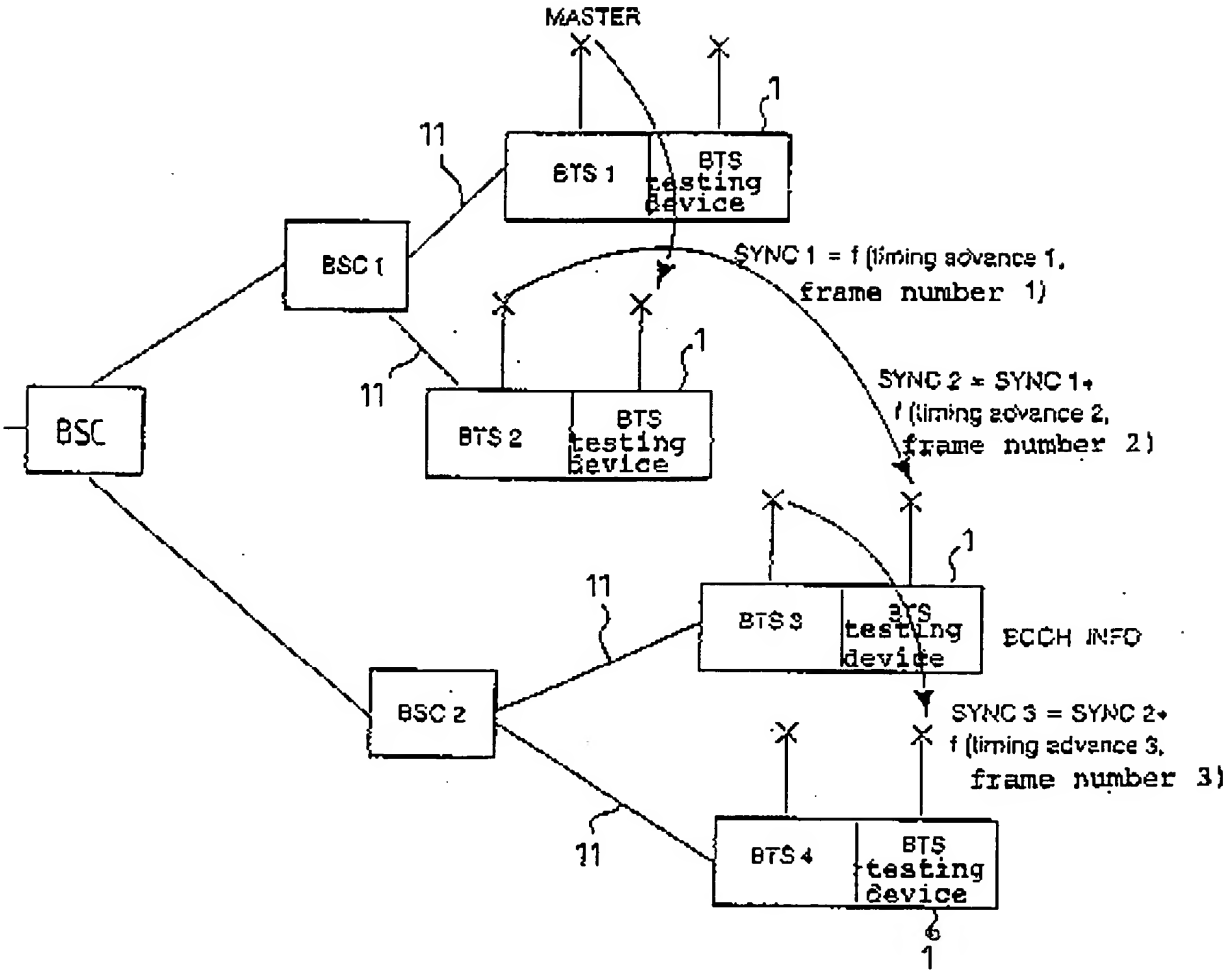

MASTER
1
11
BTS 1
BTS testing device
BSC 1
SYNC 1 = f (timing advance 1, frame number 1)
BSC
11
1
BTS 2
BTS testing device
SYNC 2 = SYNC 1 + f (timing advance 2, frame number 2)
1
11
BTS 3
BTS testing device
BCCH INFO
BSC 2
SYNC 3 = SYNC 2 + f (timing advance 3, frame number 3)
11
BTS 4
BTS testing device
1

FIG. 3

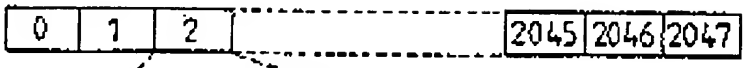


FIG. 4A

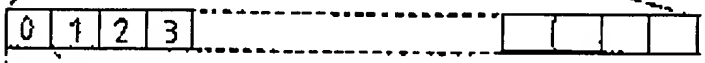


FIG. 4B

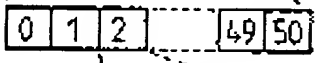


FIG. 4C

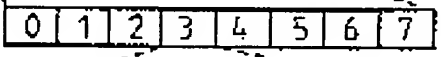


FIG. 4D

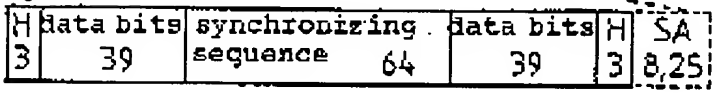
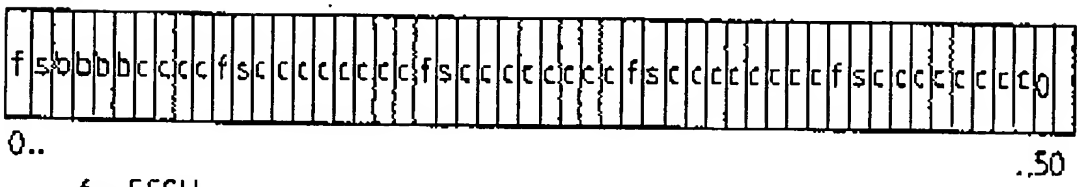


FIG. 4E



f = FCCH
s = SCH
b = BCCH
c = CCCH

FIG. 5